MEMORANDUM
RM-3370-PR
NOVEMBER 1962

THE OXNARD BASE MAINTENANCE MANAGEMENT IMPROVEMENT PROGRAM

Chauncey F. Bell and T. C. Smith

This research is sponsored by the United States Air Force under Project RAND — Contract No. AF 49(638)-700 — monitored by the Directorate of Development Planning, Deputy Chief of Staff, Research and Technology, Hq USAF. Views or conclusions contained in this Memorandum should not be interpreted as representing the official opinion or policy of the United States Air Force. Permission to quote from or reproduce portions of this Memorandum must be obtained from The RAND Corporation.

The RAND Corporation
1700 MAIN ST • SANTA MONICA • CALIFORNIA

PREFACE

This Memorandum is part of a long-term study of maintenance information requirements and analysis techniques and their effect on Air Force capabilities. It specifically attempts to increase markedly the usefulness of the present Air Force Manual AFM 66-1; Maintenance Management, at base level.

The test program reported on herein was initiated in late 1961 at the request of Hq. USAF, with the concurrence of Hq. ADC, the 28th Air Division of ADC and Oxnard Air Force Base, an ADC unit operating F-101B aircraft.

This Memorandum presents the text of a briefing given in October, 1962, at Oxnard Air Force Base, Hq. 28th Air Division, ADC, Hq. ADC, and Hq. USAF.

Related work which the reader may find useful includes:

Bell, Chauncey F., Influence of Resource and Policy Changes on Aircraft Capabilities, The RAND Corporation, R-382 (AD 266147), August 1961;

Smith, T. C., Command Management of F-102A Readiness (U), The RAND Corporation, RM-2436, August 18, 1959 (Secret).

Smith, T. C. Managing Strike Alert Commitments (U), The RAND Corporation, RM-2599, June 24, 1960 (Secret).

Stoller, D. S., and R. L. Van Horn, Management Information for the Maintenance and Operation of the Strategic Missile Force, The RAND Corporation, RM-2131, April 30, 1958.

Smith, T. C. Managing Shop Workloads, The RAND Corporation, RM-3003-PR, January 1962.

The authors express appreciation to A.F.M. Sweetland for his assistance in developing the daily information displays presented herein, particularly for the special programming efforts.

SUMMARY

In mid-1961 RAND and Hq. USAF agreed to conduct a program at Oxnard Air Force Base to improve the usefulness of AFM 66-1 data for managing the base maintenance complex. After several months of preliminary study, RAND and Oxnard personnel instituted a test program in March 1962, which included minimum augmentation of the required AFM 66-1 data collection program.

The study's primary objective was to accurately identify the maintenance generated by operational requirements, both in the amount of work and the time at which it was required. Such an identification is necessary in order to evaluate flying schedules, estimate the resulting workloads, and plan work schedules to minimize overtime. It was hoped that use of improved information would also improve the organization's alert posture, assist in establishing and justifying personnel requirements, and improve the accuracy and completeness of the data.

This report (prepared as a briefing for presentation at several ADC locations as well as Hq. USAF) reviews the results and efforts to date. It demonstrates the feasibility of the data acquisition and processing; answers key questions posed by Oxnard management personnel; and explains and demonstrates several of the graphic displays developed to assist in base management action.

Prior to this study, Oxnard management could tell from their maintenance records what was done, who did it, and the manhours consumed. Improvements since inception of the program include:

(1) Information about the time when work was first known to maintenance and when it was done;

(2) Identification of delays in returning aircraft to operational readiness;

(3) Summary of manpower utilization, by hour, day, aircraft, etc., for personnel requirements determination and for work-shift planning for any given flying program;

(4) Recording of job elapsed times in addition to job frequency;

(5) Computation of sortie recovery capabilities;

(6) Examination of impact of maintenance and operations scheduling on the flight program and on operational readiness;

(7) Greater data accuracy through a number of cross-audits.

Oxnard and 28th Air Division interest in the management benefits possible from the program led to their implementation of an augmented test beginning in September, 1962. While this report only shows results obtained in June and July, methods of analysis, presentation and other ideas developed up to the time of the briefing are also included.

CONTENTS

I. OBJECTIVES AND RESULTS

At both the 1961 and 1962 World-Wide Maintenance Management Conferences, reports from the several commands as well as the Inspector and Auditor Generals, indicated that the Air Force Manual AFM 66-1 data collection program was not being used effectively for base maintenance management purposes, although the By-Products were finding a good reception. Shortly after the 1961 conference, RAND and Hq. USAF agreed a program should be conducted at Oxnard Air Force Base to improve the usefulness of AFM 66-1 data for managing a base maintenance complex. RAND and Oxnard personnel spent several months of joint efforts examining the usefulness of the 66-1 information system in providing answers to questions and problems confronting the group commander and his management staff. Only after several tests, and comparison of official 66-1 records with special status records collected for two control aircraft, did the investigating team decide that selected, minimum augmentation of the maintenance records for F-101 aircraft should be undertaken to provide certain missing information; a test program was instituted to meet the base's management information requirements.

The Oxnard Test Directive, published in March 1962, stated that the test's primary objective was to accurately identify the maintenance generated by operational requirements, both in the amount of work and the time at which it was required. Such identification was necessary to evaluate flying schedules, estimate the resulting workloads, and plan work schedules in order to reduce to a minimum time spent on-duty when there was no work to be done. Inherent in this objective, of course, was the desire to improve the alert posture in

accordance with Air Defense Command Manual (ADCM) 65-6, Logistics Support Plan for Improving ADC Alert Posture, June 1, 1962. In addition, base management wanted to establish and justify maintenance personnel requirements, accurately reflect personnel utilization, and reduce overtime to a minimum. Information gained from review of the records on the control aircraft, as well as RAND experience with other test projects, indicated that aircraft delay situations were contributing an unknown amount of degradation to combat capability. And last, even though AFM 66-1 error rate reports for Oxnard were satisfactory, several inconsistencies in the data raised questions about its accuracy and usefulness for base management purposes. Table 1 summarizes the test objectives.

Table 1

TEST OBJECTIVES

- Accurately Identify Maintenance Generated by Operational Requirements to:
  - Evaluate Flying Schedules
  - Estimate Workloads
  - Plan Work Schedules
- Improve Alert Posture
- Establish and Justify Personnel Requirements
  - Reduce Overtime
- Identify Aircraft Delay Situations
- Improve Accuracy of AFM 66-1 Data

To date, the Oxnard test has demonstrated the feasibility of both the recording and subsequent handling of the augmented data. The test has answered key management questions which were not heretofore available in the basic data. Graphic displays, using both manual and computer analyses, have been developed for management action. Oxnard

and 28th Air Division interest in the management benefits possible from the program caused them to implement an augmented test in September 1962. This program is intended to: simplify data collection requirements; improve control of overtime; improve identification of delays; include all aircraft assigned to the base; include most shop repair activities; and begin to integrate maintenance, operations and manpower records. Table 2 illustrates the test results.

Table 2

TEST RESULTS

- Feasibility of Data Acquisition Demonstrated
- Key Management Questions Answered
- Graphic Displays Developed for Management Action
- Further Testing at Oxnard Underway to:
  - Simplify Data Collection Requirements
  - Improve Control of Overtime
  - Improve Identification of Delays
  - Include all Aircraft Assigned to Base
  - Include Shop Repair Activities
  - Integrate Maintenance, Operations, and Manpower Records

This report briefly outlines the improved base maintenance management capability realized from the program. It also identifies the additional data required and shows ways it can be analyzed and presented for management decision-making pruposes. In most cases, we will be talking about results obtained in June or July, although analysis methods and information presentationsdeveloped since that time will be included.

II. MANAGEMENT INFORMATION IMPROVEMENTS

Table 3 briefly outlines some of the management information improvements made possible since inception of the program.

Table 3

MANAGEMENT INFORMATION IMPROVEMENTS

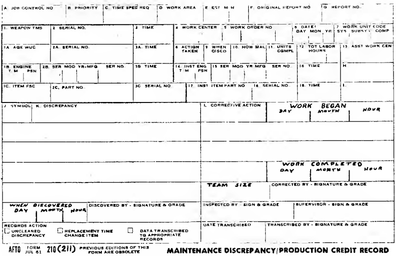
- Records now indicate the time:
  - When Work was First Known
  - When It was Done
- Delays in Returning Aircraft to Operational Readiness are identified
- Manpower Utilization (by hour, day A/C, Etc.) can be established for:
  - Personnel Requirements Determination
  - Workshift Planning
- Job Elapsed Times are Known
- Can make Computation of Sortie Recovery Capabilities
- Can Examine Impact of Maintenance and Operations Scheduling
- Greater Data Accuracy is possible through Cross-Audits

Four additional entries in AFTO Forms 210, 211 and 212 (used to document maintenance actions performed on F-101 aircraft) helped bring about the improvements listed above. Figures 1 and 2 illustrate changes made in the forms. Incorporated information includes the day, month and hour that: (1) the maintenance personnel discovered or knew about the malfunction, discrepancy or job, (2) work began, (3) work was completed. The fourth incorporated item asks for team size. Improvements also came about through the Delay Report Form -- Fig. 3. The form is filed any time work on the aircraft is delayed or interrupted for fifteen minutes or more. The work unit code is used to identify work being delayed, and the report shows by day,month and hour the time the delay began and ended. Figure 4 shows the codes used to explain the delay.

More improvements are incorporated into the system through data recorded for the 110 reports that show aircraft out-of-commission for unscheduled maintenance, periodics, tech-order compliance, NORS, etc., and, operations information is recorded by aircraft tail number, showing by takeoff and landing time when F-101 sorties were flown and whether the flight was cross-country, test flight, pilot training or intercept training. Information from these several forms and records is keypunched and programmed into a computer for display and analysis.

Two daily displays are prepared for base maintenance management use. The first is the daily status record of aircraft by serial number; the second is a record of work performed by each work center. Figure 5 illustrates the format of the aircraft status display. It should be noted that the display (Fig. 5) has been designed to show not only what happened, but much of what didn't happen to the aircraft throughout the day. This example deals with F-101 aircraft Serial Number 268, on 11 September.

Clocktimes from midnight through the day until midnight appear across the top of Fig. 5, and events are displayed as they occur so that activities in connection with the aircraft go from upper left to lower right. The right-hand side of the chart shows details concerning the activities. The headings at the top are Work Unit Code, to identify what was done; Work Center, to identify who performed the work; Elapsed Time; Computed Manhours, the elapsed time multiplied by the team size; Total Manhours, as reported in Block 12 of the AFTO Form; Action Taken; When Discovered; and Type of Work.



A. JOB CONTROL NO.	B. PRIORITY	C. TIME SPEC REQ	D. WORK AREA	E. EST M H	F. ORIGINAL REPORT NO.	G. REPORT NO.
1. WEAPON TMS	2. SERIAL NO.	3. TIME	4. WORK CENTER	5. WORK ORDER NO.	6. DATE! DAY MON YR	7. WORK UNIT CODE SYS SUBSYS COMP
1A. AGE WUC	2A. SERIAL NO.	3A. TIME	8. ACTION TAKEN / 9. WHEN DISCO	10. HOW MAL / 11. UNITS COMPL	12. TOT LABOR HOURS	13. ASST WORK CEN
1B. ENGINE T M PSN	2B. SER MOD YR-MFG SER NO.	3B. TIME	14. INST ENG T M PSN	15. SER MOD YR MFG SER NO.	16. TIME	H.
1C. ITEM FSC	2C. PART NO.	3C. SERIAL NO.	17. INST ITEM PART NO.	18. SERIAL NO.	18. TIME	I.

J. SYMBOL | K. DISCREPANCY — L. CORRECTIVE ACTION

WORK BEGAN: DAY MONTH HOUR

WORK COMPLETED: DAY MONTH HOUR

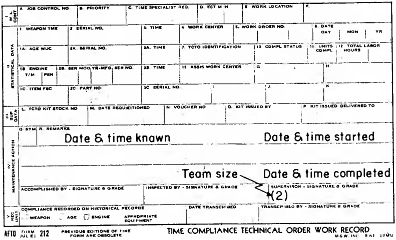
TEAM SIZE — CORRECTED BY - SIGNATURE & GRADE

WHEN DISCOVERED: DAY MONTH HOUR — DISCOVERED BY - SIGNATURE & GRADE — INSPECTED BY - SIGN & GRADE — SUPERVISOR - SIGN & GRADE

RECORDS ACTION: UNCLEARED DISCREPANCY — REPLACEMENT TIME CHANGE ITEM — DATA TRANSCRIBED TO APPROPRIATE RECORDS — DATE TRANSCRIBED — TRANSCRIBED BY - SIGNATURE & GRADE

AFTO FORM JUL 61 210 (211) PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE — MAINTENANCE DISCREPANCY/PRODUCTION CREDIT RECORD

Fig. 1 -- Maintenance Discrepancy/Production Credit Record



A JOB CONTROL NO | B PRIORITY | C TIME SPECIALIST REQ | D EST M H | E WORK LOCATION | F
I W L CONT

1 WEAPON TMS | 2 SERIAL NO. | 3 TIME | 4 WORK CENTER | 5 WORK ORDER NO | 6 DATE DAY MON YR
1A AGE WUC | 2A SERIAL NO. | 3A TIME | 7 TCTO IDENTIFICATION | 10 COMPL STATUS | 11 UNITS COMPL | 12 TOTAL LABOR HOURS
1B ENGINE T/M PSN | 2B SER MOD YR-MFG SER NO | 3B TIME | 13 ASSIS WORK CENTER | G | H
1C ITEM FSC | 2C PART NO | 3C SERIAL NO | I | J | K
II STATISTICAL DATA

L TCTO KIT STOCK NO | M DATE REQUISITIONED | N VOUCHER NO | O KIT ISSUED BY | P KIT ISSUED DELIVERED TO
III SUP DATA

Q SYM | R REMARKS
Date & time known
Date & time started
Team size
Date & time completed
ACCOMPLISHED BY - SIGNATURE & GRADE | INSPECTED BY - SIGNATURE & GRADE | SUPERVISION - SIGNATURE & GRADE
(2)
IV MAINTENANCE ACTION

COMPLIANCE RECORDED ON HISTORICAL RECORDS | DATE TRANSCRIBED | TRANSCRIBED BY - SIGNATURE & GRADE
WEAPON AGE ENGINE APPROPRIATE EQUIPMENT
V REC UNIT

AFTO FORM 212 JUL 61 PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE TIME COMPLIANCE TECHNICAL ORDER WORK RECORD

Fig. 2 -- Time Compliance Technical Order Work Record

DELAY REPORT

BASIC WORK CENTER	WORK ORDER NUMBER		DAY MO YR	WORK UNIT CODE
ASSISTING WORK CENTER	DELAY CODE	DELAY TIME	DELAY DAY	BEGAN MONTH HOUR
			DELAY DAY	ENDED MONTH HOUR

SIGNATURE:

MME TEST FORM 6 Sep 62 FC: 4400

Fig. 3 -- Delay Report

PERSONNEL -	1NA 1AA	NOT AVAILABLE AWAITING ASSISTANCE
EQUIPMENT AND FACILITIES -	2GP 2RU 2XX	GROUND POWER EQUIPMENT RUNUP PAD OTHER
PARTS -	3NA 3DD 3BC	NOT AVAILABLE ON BASE DELIVERY DELAY AWAITING BENCH CHECK COMPLETION
PERSONNEL OR MILITARY REQUIREMENTS -	4XX	(LUNCH, MILITARY TRAINING, COMMANDER'S CALL, ETC.)
DEFERRED -	5SO 5CM 5SX 5PP 5XX	OPERATIONAL SCHEDULE CONFLICTING MAINTENANCE SPECIAL EXERCISE PRELIMINARY PREPARATIONS OTHER
MISCELLANEOUS -	6XX	
WEATHER -	7XX	

Fig. 4 -- Aircraft Delay Codes (Oxnard Test)

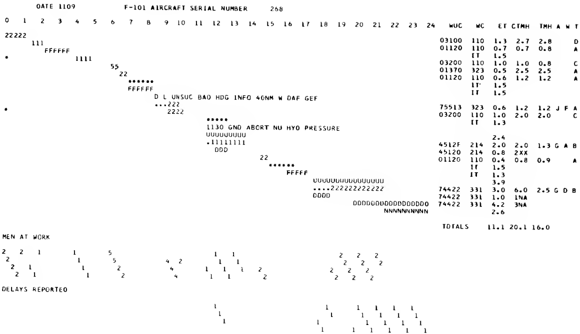


Fig. 5 -- Daily Aircraft Status Display

Now, for example, a 2-man team was at work from midnight until about 0115 (each entry covers a 15-minute interval) from Work Center 110; the Crew Chief and his assistant were performing a preflight inspection. The elapsed time multiplied by two gives the computed manhours. This checks closely with the manhours reported. "D" indicates a preflight, in this case duplicating the work unit code information. Shortly after completion of this work, 1 man, again from Work Center 110, spends about 45 minutes in parking or pre-taxi operations. The airplane then flew. Under the Work Center Column the flight code indicates that it was an intercept training flight lasting 1.5 hours. A basic post-flight inspection next takes place between 0400 and 0500 using 1 man. The asterisk to the left indicates that the time-discovered block was not filled in. In this case the rules are that it was not required because the operation was servicing, but this is a useful part of the cross-audit procedure.

At 0700 are a series of asterisks. These indicate that an intercept training flight of 1.5 hours has been scheduled for this time. The string of F's immediately below indicate that it was carried out as scheduled, although the data link was unsuccessful due to the bad heading information, etc. The present Oxnard program prints out information concerning data link or ground aborts. Incidentally, we now know that the 0215 flight was not on the scheduled program for this aircraft (no asterisks), so it was probably a scramble mission. The three dots under the data-link story indicate that although job 75513 was known to maintenance, there was a delay of approximately 45 minutes before the 2-man team from Work Center

323 (Armament) showed up for work. A delay report should have been filed telling the reason. Then another flight was scheduled shortly before noon, but was aborted due to lack of hydraulic pressure, so the airplane was placed in out-of-commission-for-unscheduled-maintenance status. Prior to this point it had been carried as an in-commission aircraft according to the official status records. Again there was a short delay (the dot) before Work Center 214 begins work; and shortly after this man began work it was interrupted for 0.8 hours because equipment was not available (code 2xx).

Notice that the next scheduled flight takes off about an hour late; afterwards the aircraft is again out-of-commission for unscheduled maintenance. There is a delay of an hour because personnel are not available from Shop 331; then some time after work does begin there is another delay, this time because parts are not available on the base. Although this fact was known at about 2000, the status was not changed from "U" to "N" (NORS) for nearly two hours.

Information across the bottom of the page summarizes the total men at work, and the total number of delays reported at any time.

Information management would look for on this display includes such items as the 45-minute delay between the end of the second flight and the beginning of work; what kind of action was taken in connection with the ground abort; reason, if any, for the late flight at 1600; the fact that the non-availability of manpower in Work Center 331 added one hour on to the out-of-commission-for-unscheduled-maintenance status, and the lag in changing the status from "U" to "N". In addition, management could examine the clocktime and manhours taken

in performing the various operations. Data accuracy checks can be made both by observing the time when work was performed and noting differences between computed and reported manhours. In this latter connection the computer counts total elapsed time, so it is necessary to subtract delay times. For instance, Work Center 331 had 2 men assigned for a 3-hour period. This gives a total of six manhours, although only 2.5 were reported. Note two lines down, however, that there was a 1.8 hour delay. When taken into consideration, this indicates that the 2.5 manhours is correct insofar as work performed is concerned. Inconsistencies or annoyances such as these will be overcome as more experience is gained or as revised AFTO 200 forms may be developed.

For the first time, we believe, most of the basic facts have been gathered together on one record to assist in evaluating the status of and work performed on individual aircraft. With these innovations, it is possible each day for relevant management -- the crew chief, workload and maintenance control, and so on, up to the squadron or wing commander to have the story of what happened or did not happen throughout the preceding day to each aircraft on the base. Information is available to determine whether certain jobs took too long, whether there was an unnecessary amount of unexplained work interruption, and how these delays affected the flight schedule and operational readiness of the organization.

For the benefit of the chief of maintenance and higher management levels, a summary report of each day's activities is desirable. Figure 6 shows how such a report might look. Each aircraft, identified by serial number, has its activities described on three lines. The

```
                DATE  0000       DAILY AIRCRAFT  SUMMARY

    T/N 0   1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24

    259                                   *****                                                  ****
    259 UUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUU+++++++FFFF++UUUUUUUUUUUUUUUUUUUUUUUUU
    259 DDDDDDMMMMMMMMDDDDDDDDDDDDDDDDDMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM MM              DDMMMMMMDDDMMDMMDDMMMM

    268
    268 HHHHHHHHNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUU+++++
    268 DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMDDDDDDDDDMMMMMMMMMMM  MMMMMMMMMMMMMMMMMM

    413                                                      *****                  *****
    413 +++++++++++++++++++++++++++++++++++++++++++++++++++++FFFFF++++++++++++++FFFFFF+++++++++++++++++++++++++++
    413                          MMMMMMMMM    MM   MMMMM                                 MM   MMMMM   MMMMM

    419                                 *******              *****                 *****
    419 +++++++++++++++++++++++++FFFFFFF+++++++++++++UUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUUU
    419                                          MM           MMMMMMMMMMMMMMMMMMMMM     MMMM  MMMMMMMMM

    424
    424 ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
    424

    426                                 *******            *****                *****
    426 +++++++++++++++++++++++++FFFFFFF+++++++++++FFFFF+++++++++++++FFFFFF++UUUUUUUUUU+++++++++++++++
    426                                        MM                                    MMM   MM

    435
    435 PPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPP
    435                                                         MMMM  MMMMMMMM      MMMMMMM       DDDDMMMMMMMMMMMM

   F101B AIRCRAFT    STATUS        DATE   0000

  READY 12  12  12  12  12  12  12  12  12  12  12  12  11  12  12  13  13  12  10   9  10  11  11  12  12      AV
                                                                                                               11.7
  UNSCH  1   1   1   1   1   1   1   1   3   3   3   3   4   3   3   3   3   4   6   7   6   5   5   4   4
  PER    1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1      3.2
  HRLY   1   1                                                                                                 1.0
  TDC                                                                                                          0.0
  NORS   1   1   2   2   2   2   2   2   1   1   1   1   1   1   1                                             0.0
  OTHER  1   1   1   1   1   1   1   1                                                                         0.8
                                                                                                               0.2

  TOTAL 17  17  17  17  17  17  17  17  17  17  17  17  17  17  17  17  17  17  17  17  17  17  17  17  17     16.9
```

Fig. 6 -- Daily Aircraft Summary

first indicates the flight schedule for the day. The second gives the status -- + for ready, F for flying, U for unscheduled maintenance, etc. The third tells the maintenance situation -- a blank if no maintenance is required, M if any maintenance is underway, and D if a maintenance need is known but not being carried out. If an individual aircraft status display shows a D and an M concurrently, this summary shows it as an M. At the bottom of the page is a status summary for the organization by hour, and the average status for the day, a report which might go to higher headquarters.

The other basic daily display shows the work performed on the previous day by each work center. This information is available to each work center supervisor and to higher management levels. Figure 7 illustrates such a display; it shows Work Center 99358 (the Instrument Shop) for 2 September. The display gives an overall picture of work performed in this shop on this day, whether in connection with an aircraft or on routine parts repair. The layout is the same as the other display, except that Tail Number is substituted for Work Center in the column to the right of the Work Unit Code. At the bottom of the page is a manpower summary.

Ten men were assigned to the shop. Two were not scheduled as available. The remaining 8 were scheduled to work -- 4 on the 1st shift (0800 to 1600), 4 on the 2nd shift (1600 to 2400), and none on the 3rd shift (2400 to 0800). By adding clocktimes to the Exception Time Accounting Card (ETA) which reports overtime, we find that this shop worked from 2 to 4 people overtime during the afternoon and evening hours. Personnel absent for reasons described by ETA Codes

```
      DATE 0209      WORK CENTER 99358

0   1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24   WUC    TN    ET CTMH   TMH A W T

                                   11                                                              GN231 4461  0.5  0.5   0.5 B M D
                                      .2222222222222222222                                         23540  413  5.0 10.0  10.0 P F B
                                                   1111                                            51151  451  1.0  1.0   1.0 C F B
                                                       22222222                                    GR310  441  2.0  4.0   4.0 C F B
                                                           2222                                    51150  451  1.0  2.0   1.0 V Q B
                                      .....................2222                                    23541  413  1.0  2.0   2.0 K F B
                                                               222222222222                        23540  434  3.0  6.0   6.0 P D B
                                                                   11111111                        23616  428  2.0  2.0   2.0 P O B
                                                                   11                              1212A  428  0.5  0.5   0.5 C F B
                                                                   11111111                        46152  413  2.0  2.0   2.0 G O B
                                                                     11                            1212A  413  0.5  0.5   0.5 C F B
                                                                     222222222222                  51150  413  3.0  6.0   6.0 V F B
                                                                       22                          51139  413  0.5  1.0   1.0 B F B
                                                                    .....2222222222222222          51133  413  4.0  8.0   8.0 P A B
                                                                               1111                51270 6047  1.0  1.0   1.0 P O B
                                                                                   1111            AA340 0014  1.0  1.0   1.0 G F B
                                                                                     22            51150  413  0.5  1.0   1.0 V F B
                                                                                         DDDDDD    51133  413  1.5  1AA

                                                                                                     TOTALS    28.5 48.5 47.5

MANPOWER  SUMMARY              ASSIGNED  10          NOT AVAILABLE   2

    MEN AT WORK
                                   1   2   2   2   3   4   6   2   5   8   4   5   3   2
                                    1   2   2   2   3   4   6   2   5   8   4   5   3   2
                                        2   2   2   3   4   6   2   7   8   4   3   5
                                         2   2   2   3   4   6   2   7   8   4   3   5

    SCHEDULED FOR WORK
    0   0   0   0   0   0   0   0   4   4   4   4   4   4   4   4   4   4   4   4   4   4   4   4

    OVERTIME
    0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   2   2   4   4   4   2   2   0   0

    ABSENT (ETA CODES 30-46)
    0   0   0   0   0   0   0   0   0   1   1   1   1   1   0   0   0   0   0   0   0   0   0   0

    AVAILABLE FOR WORK
    0   0   0   0   0   0   0   0   4   3   3   3   3   3   4   6   6   8   8   8   6   6   4   4
```

Fig. 7 -- Daily Work Center Display

30-46 are picked up in the same fashion and the number of men available for work hour-by-hour is derived as the total of those scheduled for work plus those working overtime minus those absent. Thus it is possible to determine if the shop was working up to capacity or could have handled more work.

These, then, are the new displays available on a daily basis to maintenance management at base level. The aircraft displays focus attention upon the prime weapon-- the basic reason for the organization's existence. The work center displays provide needed backup information on one of the critical resources -- personnel. Potential problems, trouble spots, or data inconsistencies, are identified before they become serious. Thus management control really begins with a daily review of yesterday's activity. Summaries of this activity are appropriate for higher levels of command.

The next part of our report concerns other analyses of the data to find answers for questions involving manpower requirements, work-shift schedules, recovery capabilities and the flying program.

III. ANALYSIS

Oxnard maintenance shops or work centers fall into the conventional categories -- engine, hydraulic, fire control system, etc. In June, the number of men assigned to the different work centers ranged from 1 in the welding shop to more than 50 in the fire control system shop. This Memorandum uses the autopilot shop to illustrate some of the potential to be realized from analysis of the data shown on the Oxnard daily work center display.

It should be emphasized first, that the following analysis includes only the work reported for flight-line operations. It does not include all shop repairs. In addition, 2 men in the autopilot shop spent most of their time on Technical Order Compliance's (TOC's) that are not included in these data. Because the TOC workload was not typical, and since the shop experiences little field maintenance workload in any event, our analysis actually covers most of the shop's routine workload. Except for the TOC's, it includes the data identified with F-101 aircraft and thus covers the primary mission support requirements.

Figure 8, Manpower Utilization Analysis, contains the essential information. It was reproduced by means of an output from the computer which summarized all of the flight-line workload accomplished by the autopilot shop during June, 1962. Information at the top identifies the shop and work center number, and shows the number of men assigned to the shop on the Master Roster during the month. Figure 8 also shows the shop's total number of work days for the period, and the different work shifts. The left-hand side indicates the

MANPOWER UTILIZATION ANALYSIS

AUTOPILOT SHOP
WORK CENTER 99351

ASSIGNED:
9 MEN

24 WORK DAYS
JUNE, 1962

NUMBER OF MEN	3d SHIFT								DAY SHIFT								NIGHT SHIFT							
HOUR OF DAY	0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12	12–13	13–14	14–15	15–16	16–17	17–18	18–19	19–20	20–21	21–22	22–23	23–24
10																								
9																								
8					1														1			1		
7															1	1	1	2	1	2				1
6			1	1					2	2	2	1	1	1					1	4	1		1	1
5		1				1					1	1	1	1	1	3	4	2	2				1	
4	2	3	2	2	1	1		1	2				2	2	2	2	1	1	2	2	3	2	2	
3	1	2	2				1		1	1	2	3	5		3	4	2	3	3	3	2	1	1	2
2	3	2	4	3	3		1	4	7	8	8	9	5	5	6	7	8	4	3	5	7	8	5	
1	3	1	1					3	3	4	1	3	3	4	1	1		1					1	3
0	15	15	14	18	19	22	22	16	9	9	10	7	7	11	10	6	8	11	11	8	11	12	13	17

Fig. 8 -- Manpower Utilization Analysis

number of men working at the same time. The hour of the day is shown across the bottom. The numbers entered in the different cells show the number of times during the month the given number of autopilot specialists worked at the same time during the hours identified. For example, between 2400 and 0100 hours, 2 days out of 24, 4 men worked simultaneously; 1 day, 3 worked; 3 days, 2 worked; 3 days, 1 worked; and 15 days, no one worked between these hours.

The summary analysis, then, shows the number of times during the month any given number of men from this shop worked simultaneously on different jobs. Thus, it provides information on the hourly patterns of peak and low utilization. For example, during June, 8 was the maximum number of autopilot specialists used at one time. This number of men was required 3 times, once between 0400 and 0500 hours (a special exercise), once between 1800 and 1900 hours, and again between 2100 and 2200 hours.

Ignoring the few occasions when there were several people (5, 6 or 8) at the same time on the 3rd shift, you can see how the demand pattern builds up from shift to shift for several of these specialists needed on several jobs simultaneously. Peak demand is generally lowest during the 3rd shift and highest during the 2nd shift. The average number working at the same time (not shown here but computed and displayed on machine printouts) was less than one during the 3rd shift, about 2 on the day shift, and reached a peak average on the night shift of about 3 men between 1900 and 2000 hours.

One purpose of this analysis is to evaluate shop manpower utilization during the period covered in order to estimate the manpower

required to support the primary missions. It also is used to determine how the available number of men might have been divided over the three different work shifts to improve support, balance workloads, and reduce overtime. Since Oxnard received a cut in the manpower authorized for this shop (from 12 to 9) during June, 1962, our analysis concerns a current manning problem confronting Oxnard management.

Figure 8 shows how Oxnard actually utilized its autopilot specialists to support primary mission requirements but this does not complete the analysis. Since work centers sometimes do not work off jobs as soon as they are generated, it is necessary to re-examine the daily work-center displays to determine whether or not any jobs were delayed, i.e., determine how demand for these specialists was generated.

Recall that delays show up on the displays either as a series of dots indicating a delay in beginning the job after its discovery and/or as a delay record showing work interruptions and the reasons therefor. Assuming that all delays, except those for lack of personnel (Code 1NA), would have occurred in any event, and revising job begin and end times so that they would be started when generated and completed as soon as possible, the work record of this shop has been revised to reflect the manpower which would have been required to support the workload as it was generated during the month. As indicated in Fig. 9, Manpower Utilization Analysis -- Adjusted, the resulting analysis (or simulation) of Oxnard autopilot shop operations for June produced approximately the same pattern of demand shown in Fig. 8. The shaded areas show that the significant changes were

MANPOWER UTILIZATION ANALYSIS
(ADJUSTED)

AUTOPILOT SHOP
WORK CENTER 99351

ASSIGNED:
9 MEN

24 WORK DAYS
JUNE, 1962

	3d SHIFT								DAY SHIFT								NIGHT SHIFT							
NUMBER OF MEN \ HOUR OF DAY	0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12	12–13	13–14	14–15	15–16	16–17	17–18	18–19	19–20	20–21	21–22	22–23	23–24
10																								
9																		1						
8				1	1												1		2			1		
7													1			1		2	1	2				
6		1	1						2	2					1	1		1	2	2	1		1	1
5		1				1					1	1	2	1	1	3	2	2	1			1	1	
4	2	3	2	1	1	1		1			2	2	2	3	1	2	3	1	2	4	2	2	1	
3	1	1					1		2	1	1	4	4	4	5	5	2	1	1	1	2	1	1	1
2	3	2	5	4	1		1	4	6	6	6	9	4	4	7	5	6	4	2	4	5	3	4	1
1	2	1	1					3	2	2	1	2	1	3		1		1			1			2
0	16	15	15	18	21	22	22	16	12	13	13	6	10	9	9	6	10	11	13	11	13	16	16	19

Fig. 9 -- Manpower Utilization Analysis

1 demand for 9 men and 6 demands for 8 specialists to work simultaneously on several jobs, and a reduction in the number of times 6 men were at work at the same time. This analysis of the adjusted record, has been summarized in Fig. 10, Manpower Requirements Analysis, which will be used to evaluate manning requirements and work-shift arrangements for this shop.

The same information at the top of the figures identifies the work center, month, and assigned manpower. The number of men is shown on the left-hand side. The data entered in the different cells in Fig. 9 have been summarized by shift to show the percentage of demand for autopilot specialists which would have been met by the given number of men. The heavy lines shown for each shift identify the average number of men reported as available in June for work on each shift. No men were assigned duty from midnight to 0800 hours (3rd shift), 5 men were available from 0800 to 1600 (1st shift), and 3 were on duty from 1600 to 2400 (2nd shift). The other man was on leave, sick, etc.

Since no men were assigned regular duty on the 3rd shift, all work accomplished during the shift should have been reported as overtime. Similarly, work accomplished during the other shifts either represented overtime or very flexible shift arrangements for individuals in the shop. In fact, the shop reported about 20-per-cent overtime for the month of June in the K-25 report.

The answer to the question: How many autopilot specialists did Oxnard need to support June operations? depends upon several considerations. First, if management is willing to settle for 20-per-cent overtime,

MANPOWER REQUIREMENTS ANALYSIS

AUTOPILOT SHOP WORK CENTER 99351	ASSIGNED: 9 MEN	24 WORK DAYS JUNE, 1962

NUMBER OF MEN	3d SHIFT DEMANDS MET (%)	DAY SHIFT DEMANDS MET (%)	NIGHT SHIFT DEMANDS MET (%)
10			
9			100
8	100		99
7	99	100	97
6	99	99	95
5	98	96	91
4	97	91	87
3	91	85	79
2	90	71	74
1	79	47	59
0	0	0	0

Fig. 10 -- Manpower Requirements Analysis

continual changes in work shifts, some delays in work accomplishment, and the morale factors, re-up rates, etc. which follow such working conditions, then not more than 9 men were required (since about 2 of these men actually worked most of the time on TOC's, 7 men actually supported the June program). On the other hand, if this much overtime is not acceptable and if the need for rather firm (at least from week to week) work shift schedules for the men is accepted, more men were required.

Second, the number required depends upon another consideration -- policy must be provided or the Commander must decide how sure he wants to be that all jobs are started as soon as they are generated without resorting to overtime, i.e., he must decide what percentage of demands he wants to meet shift-by-shift with men on the shift. For example, the June data indicate that Oxnard needed 8 men on the 3rd shift to be sure to cover all work without resorting to overtime or other changes in working shift arrangements. Four men would have met 97 per cent of the demands, and 2 men would have met 90 per cent of the workload as it was generated.

Evaluation of the reported shift arrangement shows that the 5 men on the day shift should have met 96 per cent of all demands, while the 3 men on the night shift should have met only 79 per cent of the work as it was generated without getting help from the previous shift or delaying the work until the 3rd shift. Obviously, both help and delay solutions would result in overtime for someone. In addition, the delay to the 3rd shift would result in some aircraft delay-time and loss of aircraft OR time.

Therefore, the Commander's decision on the percentage of demands he wants to meet also implies a level of degradation he is willing to accept. For example, if he puts only 3 men on the night shift, he should accept either overtime up to 20 per cent of the workload passed on by the day shift and/or generated during this workshift or additional aircraft downtime (queue time), or some combination of both.

Given policy on these considerations the maintenance analyst can identify alternative manpower authorizations and work shift arrangements for Oxnard shops. Assuming that June was a typical month and projecting approximately the same flying program, Oxnard needs about 11 or 12 men in the autopilot shop if it cannot accept more than 9 or 10 per cent of the job delays and/or demands for overtime. The breakdown would be as follows:

3 men on 3rd shift, 91 per cent met, 9 per cent delayed
4 men on day shift, 91 per cent met, 9 per cent delayed
5 men on night shift, 91 per cent met, 9 per cent delayed
12 men total

Other shift arrangements are possible if the Commander chooses different percentages for meeting demands as they arise or if he accepts different upper bounds on overtime.

Actually, Oxnard management must consider one more factor: manpower utilization. When manhour utilization factors are computed for each manning level, an interesting situation develops. The comparable percentages are shown in Fig. 11 which also identifies the 3, 4, 5 shift-manning possibility. Please note that the original 5 men on the day shift would have shown 34-per-cent utilization and that the 3 men

MANPOWER REQUIREMENTS ANALYSIS, II

AUTOPILOT SHOP
WORK CENTER 99351

ASSIGNED:
9 MEN

24 WORK DAYS
JUNE, 1962

NUMBER OF MEN	3d SHIFT		DAY SHIFT		NIGHT SHIFT	
	DEMANDS MET (%)	UTILIZATION (%)	DEMANDS MET (%)	UTILIZATION (%)	DEMANDS MET (%)	UTILIZATION (%)
10						
9					100	18
8	100	90			99	20
7	99	103	100	24	97	23
6	99	12	99	28	95	27
5	98	14	96	34	91	32
4	97	18	91	43	87	41
3	91	24	85	57	79	54
2	90	36	71	85	74	81
1	79	72	47	100	59	100
0	0	—	0	—	0	—

Fig. 11-- Manpower Requirements Analysis, II

on the night shift would have accounted for 54 per cent utilization. Computations for the alternative 3, 4, 5 shift arrangement show 24, 43, and 32-per-cent utilization for the 3rd, day, and night shifts, respectively.

Comparison of these percentages with their companion percentages for meeting demands, especially the 24 with the 43 per cent, illustrates some of the pitfalls in using manhour utilization factors as a management tool for estimating manpower requirements. Although this tool may be appropriate for some commercial operations, it is somewhat hazardous for estimating primary mission support requirements for most of the work centers on an air base. For, in order to show 55 per cent or better utilization, this shop would have to be manned by 6 men spread over the 3 shifts: 1 for shift 3, 3 for the day shift, and 2 for the night shift, respectively. In June, such manning would have given Oxnard management confidence in meeting only 79, 85, and 74 per cent of the workload as it was generated. An average of 20 per cent of the autopilot jobs requiring overtime or being delayed for lack of specialists would be the penalty that Oxnard would have to pay to show 55-per-cent personnel utilization in this shop.

Thus, management must first decide how sure it wants to be that all demands are met as they occur, or alternatively how much degradation it can accept or cover by overtime; then it can select the manning level for each shift required to meet its objectives. If Oxnard management can accept no more than a 9-per-cent degradation, these data show that the proper manning for the autopilot shop is at least 12 men, not including those normally on leave, etc. Simultaneously,

management in all higher commands should accept the fact that manhour utilization at this level of manning will be in the order of 24, 43, and 32 per cent respectively.

September data includes shop workloads, TOC, and T-33 support requirements. Therefore, Oxnard now is in a position to analyze its total manpower requirements as have been illustrated using the autopilot shop and June data.

Another kind of analysis which has been of some concern to the Air Defense Command throughout the year involves determining recovery capability curves or sortie turnaround requirements. ADC Manual 65-6, dated 1 June 1962, refers to this requirement in the context of defining a maintenance concept as follows:

> Scheduled take-off times for sorties must be governed by factors such as local weather trends, number of aircraft available for daily scheduling, anticipated aircraft break rates, and recovery capability.

An output of the Oxnard test program has been development of two composite recovery capability curves for the F-101 weapon system. The curves are shown in Fig. 12, F-101 Composite Recovery-Capability Curves. These curves are based upon manual analysis of the tail-number displays for all F-101 aircraft in the base's possession during June. Although computer production of such a display should not be discounted, combined computer and manual analysis of the data probably insures best results at this time.

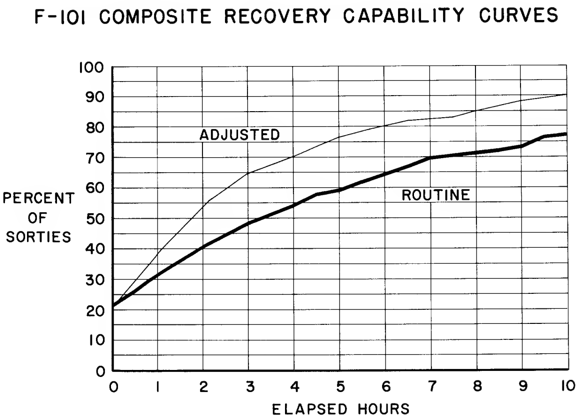


Fig. 12 -- F-101 Composite Recovery Capability Curves

The routine recovery curve shows that about 32 per cent of the Oxnard aircraft were turned around within one hour, 51 per cent within 3.5 hours, and 77 per cent within about 10 hours. A routine recovery is that actually reported. It is defined as the time elapsed from landing to completion of the last unscheduled maintenance job or the postflight, whichever was completed last. This definition excludes routine servicing actions and should coincide with the time an aircraft was called back into commission, if it was called out in the first place.

As indicated in Fig. 12, the upper curve represents an adjusted recovery capability. An adjusted recovery assumes that routine maintenance actions could be improved to shorten recovery times. It is defined as the time elapsed from beginning of the first maintenance action (unscheduled maintenance or postflight) to the end of the last job completed, after eliminating all delays and collapsing much of the work actually done end-to-end. That is, it assumes that many jobs could have been done in parallel which may have been reported end-to-end. It excludes those jobs which could not be done in parallel because they were discovered as a result of another job. Neither does it include jobs which normally would be done separately for safety reasons.

The two composite recovery curves show the gain Oxnard management might expect by resort to very tight supervision of work which would eliminate communication lags, work-shift arrangements, parts-delays, and other interruptions associated with routine, day-to-day operations. The area between the two curves represents some of the potential for such management improvement efforts.

In general, it appears that routine recovery operations at Oxnard could not be compressed more than 50 per cent, i.e., turnaround times could not be cut more than half. Specifically, 40 per cent of the turnarounds during June show a potential reduction from 2 hours for routine operations to 1 hour net work-time or adjusted recovery time. Similarly, the 65 per cent of the sorties which show 6-hour turnarounds might have been done in 3 hours under ideal conditions.

It should not be inferred from this discussion that the adjusted curve could not be pushed upward, only that each improvement probably would become more difficult than the last and would require ever-increasing attention to travel time and communication lags in order of minutes, substantial reductions in job repair times, and malfunction frequencies and other changes which probably would require intense management efforts.

Figures 13, 14, 15 and 16 summarize several steps in an analysis of a proposed flying schedule using the recovery curves derived from the June data. The figures show only that portion of the fleet normally available for day-to-day operations. They also include some of the scheduling planning factors suggested in ADCM 65-6 dated 1 June 1962. As indicated in Fig. 13, the analysis assumes that a total of 12 aircraft are in the flying fleet. It also assumes that the average condition at the start of the flying day will include one aircraft NORS, one in scheduled maintenance, and another down for unscheduled maintenance. The first two assumptions are borne out by Oxnard data. The last will be revised later. The analysis is also based on an Oxnard objective of 18 sorties per day spread over

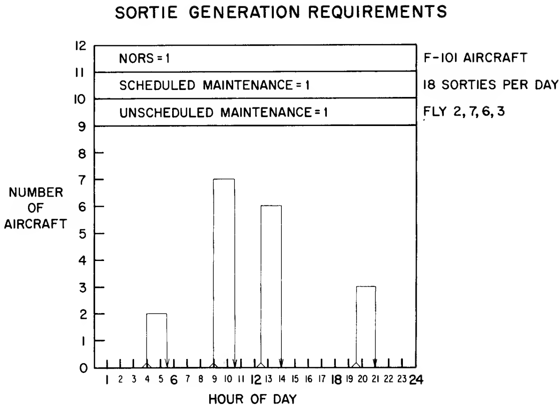


Fig. 13 -- Sortie Generation Requirements

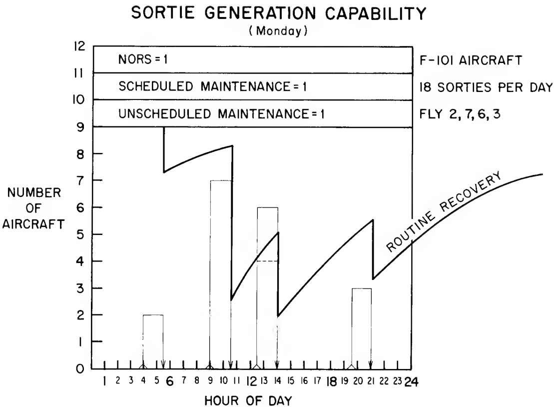


Fig. 14 -- Sortie Generation Capability

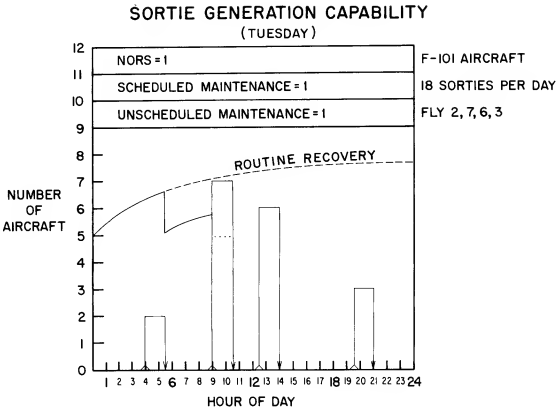


Fig. 15 -- Sortie Generation Capability

4 flying periods. The number of aircraft are shown along the side of the figure and the hour of the day at the bottom.

The arrows showing take-off and landing times depict the daily flying schedule; the height of the bar created by the arrows shows the number of aircraft scheduled for each period; namely, 2 at 0400, 7 at 0900, 6 at 1230, and 3 at 1930 hours.

The analysis starts with an assumption that the flying schedule begins on an average Monday morning and that aircraft will be in the status shown on Fig. 14 early that morning. Two aircraft out of the 9 available for flying are launched at 0400 hours. Application of the composite routine recovery curves shown on Fig. 12 shows that if the unit begins recovery immediately at 0530 hours when the aircraft land, on the average it could expect one of the two to be ready for flight by 0900 hours.

In any event, the 9 O'clock schedule calls for only 7; they are available and are launched. Maintenance continues recovery of the two aircraft launched at 0400 hours. Immediately after landing, recovery begins on the 7 aircraft launched at 0900 hours. Taking advantage of those aircraft landing without malfunctions, the curve shows that Oxnard cannot expect to launch 6 aircraft by 1230 hours. Routine operations will turnaround an average of only 4 aircraft by that time and in order to realize this number the unit must fly every available aircraft ignoring tail-number scheduling.

Let's assume that 4 are launched and that the base follows the same routine for the next recovery period. Obviously, it will encounter no difficulty flying the last period because 5 or 6 aircraft will be available by that time.

Tracing the routine recovery curve on out through the night and transposing it to the beginning of the next day (Fig. 15), reveals that if 2 aircraft are launched at 0400 hours, only 5 aircraft can be made available by 0900 hours the next day. The figure also shows that the number in unscheduled maintenance would range from about 5 at 2400 hours to 3 at 0900 and 2 by the end of Tuesday, even if no flying was attempted that day.

As will be noted, these numbers include the aircraft considered out for unscheduled maintenance all of this time. Justification for leaving one in this status rather than including it in the flying fleet is the fact that the June data show about one aircraft out-of-commission because of ground malfunctions and TCTO requirements all of the time. Therefore it accounts for maintenance requirements which are not included in the recovery curve data.

Routine recovery, then, appears to be too slow to support a 2, 7, 6, 3 program on Tuesday. If the base launches the two always available at 0400 hours, it will have only 5 or 6 to launch during the second period. The third period also will suffer and total results for the day will be something less than planned.

Figure 16 depicts Oxnard's capability to support the same flying schedule if it could achieve the adjusted recovery curve. Note that even expedited turnarounds fall short of recovering 6 aircraft by 1230 hours. As the curve shows, the base should be able to launch an average of 5 and always meet the program of 3 later in the day. Transposing the recovery curve for the end of the day into Tuesday morning, the figure shows that 7 aircraft should be back into

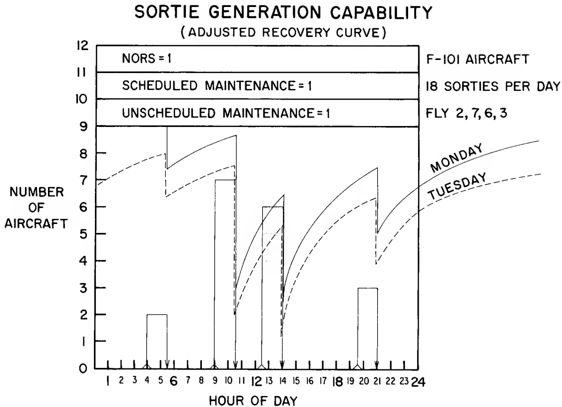


Fig. 16 -- Sortie Generation Capability

commission by 0900 hours making it possible to launch 7 at 0900 hours and another 4 during the third period.

The analysis can be repeated until the most feasible flying program has been identified. We have used this analysis of a proposed daily flying schedule to illustrate several points. First, under routine operations, Oxnard should not expect to achieve this particular schedule. Even if it could achieve the adjusted recovery curve capability, it should not expect to meet the 3rd period goals. Moreover, it should expect to have more than one aircraft in unscheduled maintenance on an average morning. Depending upon fluctuations in ground malfunctions and on the TCTO workload, the average should be at least 2 and maybe more in unscheduled maintenance.

Second, both recovery curves indicate that the 2nd and 3rd flying periods are very close together. Other reasons may dictate such schedules, but it is somewhat unreasonable to expect maintenance to meet them with much successs. Given present recovery capability, either the 2nd flying period should begin 30 minutes to an hour earlier or the 3rd should begin 30 minutes to an hour later or both, if maintenance is to be held to the 7 and 6 commitment for these periods.

Third, although Oxnard may expect to have considerable success with daily tail-number scheduling for the 1st, 2nd, and 4th periods, the 3rd period will be difficult to meet. For in order to approach the goal of 6 aircraft, it must launch every aircraft it can turnaround during the recovery period every day. It must take advantage of all "lucky" days when more than 4 or 5 are recovered to offset those days when only 3 or 4 are ready.

In summary, our purpose has been to indicate some of the new analysis potential provided by the data being collected at Oxnard. Examples of other analysis outputs being used by Oxnard management are included in the Appendix. Additional analyses concerning job standards, system break rates and recovery requirements, etc., are under development. However, this report should not be closed without emphasizing that the Oxnard base maintenance management improvement program has not degraded the management information currently available under the AFM 66-1 system. All current malfunction records, by-product reports, manhour documents, etc., remain in the system. In fact, the value of all of these products has been enhanced by improvements in the basic data from which they are derived. The 66-1 data being collected at Oxnard today are more accurate, less duplicative, and more complete as a result of the test program.

The data are more accurate because crew size, elapsed repair times, and manhours must be in agreement or be explained by appropriate delay records. They are less duplicative because duplicate records stand out so obviously on the displays and in the manpower summary. In other words, redundant pre-flights, servicings, etc., stand out. Moreover, only so many people can work on an aircraft at the same time. Padding and similar recording errors will be plainly evident in the summary data.

The data are more complete because management attention has been focused upon the weapon system and upon the sequence of actions which should follow key events. It is difficult to "forget" that some sort of maintenance action follows a sortie, that every 65-110 status

record should be accounted for by an appropriate Maintenance Data Collection record or delay report, and that each parts delay or NORS situation should have been preceded and followed by appropriate maintenance actions.

Other improvements in the validity and accuracy of the data could be cataloged, but these should be sufficient to illustrate that all follow-on analysis, including AFLC By-Product reports, begins with basic data inputs which are more accurate than they were before the new data elements were added to Oxnard records.

Given these improvements in AFM 66-1 data, base managers at Oxnard are in a position to place greater reliance upon their information. With it, they can make a wide range of decisions beginning with day-to-day adjustments in work priorities and work-shift arrangements, extending through identification of reasonable job standards and work schedules, including selection of adequate shop manning allocations and balanced work-shifts, and ending with more achievable fly-training schedules and alert commitments based upon accurate measurement of weapon system break-rates and unit recovery capabilities. We believe these improvements should be tested at other bases and in other commands.

The remarks of Lt. Col. K. L. Siegler, Chief of Maintenance, and Colonel L. T. Seith, Commander, 414th Fighter Group, who participated in briefings at Hq 28th Air Division and Hq ADC, are attached. They describe Oxnard's experience and current use of the information through mid-October, 1962.

APPENDIX

Statement of the Chief of Maintenance, 414th Fighter Group (Air Defense), Oxnard Air Force Base, California, following the RAND presentation at Hq. 28th Air Division and Hq. ADC.

Messrs Bell and Smith have given us a rather comprehensive presentation on the Oxnard Base Maintenance Management Improvement program. Now, I would like to take a few moments to tell you something of the program as it progressed at Oxnard, of its implementation, acceptance, usage, results, and some of the obvious potential which we see for it.

Maintenance management at Oxnard was eager to participate in a program designed to improve the utilization potential of the Maintenance Data system. They felt that there were inherent limitations in the system as it existed, which detracted seriously from its effectiveness. For example: there was a serious lack of recorded information portraying the time sequence of interrelated happenings within the maintenance complex. The absence of this information precluded occurrence pattern studies without extensive manual preparation and analysis and deprived supervisors of a necessary management tool. The format in which the maintenance data was presented limited its effective utilization by all supervisors, for it required extensive and time consuming manipulation and analysis by persons with a knowledge of analysis procedures. Most personnel in the maintenance complex have neither the time nor training to perform such analysis, and I suspect that the analysis section of the average ADC unit does not have suitable manning to provide each level of supervision with

the management information which it needs. The system was not supported by worker levels because benefits were not apparent. Thus accurate reporting was difficult to attain. The feeling was, that if these and other deficiencies could be remedied, the effort would be well worth while.

Implementation of the program at Oxnard was on a project basis under the monitorship of the Maintenance Analysis Section. Project officer was Captain Charles Mercer, who on the Oxnard side of the team deserves most of the credit for the progress of the program to date. The project was introduced to the maintenance personnel through the media of a project pamphlet, 66-1-4, and numerous group and individual indoctrination sessions. Every effort was made to instill a receptive atmosphere for the project by outlining its objectives. Admittedly, some resentment was noticed within the organization at first. However, as time went on and personnel began to see the products, they began to feel that here was information which was useful to them without devoting extensive time to interpretation and analysis.

Although we have been working at this a year, we have only achieved a useable format and presentation in the past few months. This test really began for Oxnard on September 10.

In the beginning, the daily aircraft and shop displays were reviewed by the Group Commander, the Chief of Maintenance, and the Maintenance Analysis officer. Some glaring examples of erroneous and incomplete reporting, unexplained delays, and improper supervision of personnel, were reflected. It was obvious that to get the needed

accuracy in source data, and correct other indicated deficiencies, it was necessary to get these daily runs down to the lower levels of supervision. This was difficult to do with only four copies, so at my daily 0900 meeting I reviewed the runs with the maintenance officers. This procedure had advantages and disadvantages. On the plus side, skepticism was erased and replaced by enthusiasm for the possibilities of the system. On the minus side, these meetings were tedious and time consuming. Initially the officers were not closely enough associated with the minute details of their functional elements to explain the patterns on the runs and thereby take corrective action. At this time it became evident that we needed more runs so we could get analysis down to the shop chief level. We asked RAND to provide eight runs each day and they graciously complied, so we now distribute the daily runs to selected NCOs at 0800. They are then evaluated down to crew chief or specialist level and the officer in charge is briefed. I then have a short meeting at 1300 daily with all officers wherein we discuss the details of the previous day's activities. At all levels of review, problems or unusual occurrences are discussed and steps are taken to prevent recurrence. The result is that all levels of management now have a much more comprehensive knowledge and understanding of what is going on in their area of responsibility. Problems are clearly understood and corrective action is being taken.

Some of the discrepant areas which have come to our attention through use of this system, and which we have taken action to correct are:

Inaccurate reporting of maintenance data. Such things as reporting work on an aircraft while it was flying, using erroneous work unit

codes, and flying aircraft in a NORS status. We have been able to spot such defects in our reporting quickly and easily and have, we believe, attained a degree of accuracy higher than we have had before, if only because the workers are having to account for data reporting discrepancies.

Another discrepant area concerns delays in the production elements, which affect the flight schedule and the OR rate. These delays are in the nature of: jobs extending over the standard time limit; unexplained job interruptions: transportation and communications limitations; parking and debriefing losses; specialists dispatched late or not available; equipment and facilities delays, and inefficient scheduling such as poor timing, failure to schedule concurrent jobs, etc.

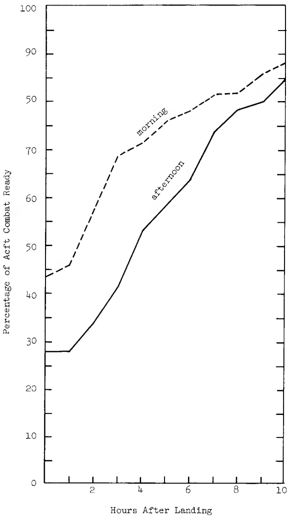
In attempting to solve these delay problems, we have tightened our work load control procedures to assure expeditious dispatch of specialists and equipment, to maintain closer surveillance over work by making frequent progress checks, and by pre-planning as much work as possible. The shop chiefs, flight chiefs and crew chiefs, who are now getting a picture of how their work fits into the over-all pattern, are developing a healthy sense of urgency which can only result in reducing delays. Thus, this system is also an excellent training device for maintenance planners, schedulers and controllers.

We are now studying our post-mission debriefing and planning procedures in order to reduce lag in turn-around of aircraft. We have studied the work load pattern of our shops, and have taken action to improve our schedules to provide better coverage of work without resorting to overtime.

We have found this system to offer great potential in showing us those areas which cost us the most in maintenance production and in pointing out where we can achieve the most gain in our management. For example: We are now studying the scheduling of training and other requirements so as to minimize their impacts on the production effort. These data actually show us the slack periods in the day, where training can be scheduled without hurting production. One other feature which we feel to be of prime importance is the capability to study such things as recovery rates under different operating conditions. On the following figure we see the recovery curves for morning and afternoon periods. We are now investigating the reasons for the difference, and hope to bring the recovery rate of the afternoon mission more in line with that of the morning mission.

A great advantage to the system is its adaptability to the needs of an individual unit. One example of this is our inclusion of data link sortie information as a verbal display on the daily runs as you saw.

There may be a question about the costs involved in applying this project at Oxnard. In reality, costs in manpower and materiel were relatively light with the exception of these directly involved in the experimental phase. One local form was developed on which to report delays, and the punch card operation was moved to maintenance for control purposes. The bulk of the costs were involved in transporting and handling cards and machine runs to and from RAND, who has been providing computer time during this test phase.



Morning and Afternoon Aircraft Recovery Curves

Statement of the Commander, 414th Fighter Group (Air Defense), Oxnard Air Force Base, California, following the RAND presentation at Hq. 28th Air Division and Hq. ADC.

Following are a few comments from the unit commander's viewpoint. First, it should be clear that this proposal is not a new maintenance system; it doesn't modify the basic AFM 66-1 concept. It does, however, greatly facilitate maintenance management control at base level, by facilitating direct management over the aircraft itself and over the hour-by-hour utilization of maintenance personnel. It can be said that all of the recent management improvement steps taken at Oxnard were, after all, only steps dictated by common sense in the first place. The real point here is that the new data fosters a degree of lateral and vertical flow of information, seldom achieved before -- certainly not at Oxnard. The result: Problems that were previously obscured or at best, vaguely understood, become more clear to the people who have to make the decisions -- shop and flight chiefs, maintenance officers, and managers alike.

This data will be used at base level because it is truly useful there. Its usefulness, coupled with the cross audit feature, should result in much better accuracy in maintenance data, with resultant benefit to the Air Force supply, procurement, and product improvement programs.

At Oxnard this data was an augmentation of existing requirements; nevertheless the added reporting workload proved to be relatively light. One of the many advantages of the system lies in its potential for consolidation of many maintenance and operations reports and

forms which now litter the scene. Additionally, there is good potential for a revamp of present analysis reports into periodic studies of greater value to managers and chiefs throughout the maintenance complex.

This data has potential for all types of operations; however, there may be pitfalls in conclusions drawn from the test at Oxnard. We should also test the system at larger bases; for different types of aircraft operation, e.g. SAC or MATS; for missile units; and for ground radar.

The potential of the data should be clearly understood by the several levels of base maintenance management prior to test implementation. If the testing organization views this as just another piece of bookwork dropped on top of the already loaded mechanic, then the test cannot but prove the new data to be useless.

A change in manhour utilization figures should be expected of units using the data. Some (most it is suspected) will show a drop in direct manpower utilization and in maintenance manhours expended per flying hour, without corresponding changes in real workload. This occurred at Oxnard as data was "purified." Others could conceivably show the opposite result.

Established manpower yardsticks, as applied to maintenance data, should not be applied to units using the new data collection system. The repercussions on mission capability in this case could be serious.

RECOMMENDATIONS:

a. Continue the test at Oxnard AFB with the aim of further refining data, admin procedures and computer programs.

b. Provide computer time to support the Oxnard operation independent of Rand Corporation computer support. It is believed that computer time can be purchased at nearby military installations.

c. Establish firm responsibility within the Air Force for test and development of this project.

d. Set up test programs in other types and size Air Force units to establish, with certainty, the universal application of this concept and to gain further experience in its use.

e. Use extreme caution in applying manpower yardsticks to units testing the system and waive maintenance manpower utilization standards for these units.

f. Continue to develop the concept toward its full potential. Objectives are:

1) Consolidate various operations and maintenance reports and forms.

2) Develop better and more useful maintenance analysis models and reports.

3) Achieve simplified means of providing needed manpower time accounting data, in conjunction with new maintenance data.

4) Establish more valid and useful work center data.